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IDENTIFICATION OF BRAIN TUMOR BY ANN APPROACH DERVIVED FROM BPN AND PNN

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Abstract: *This paper presents the application of artificial neural network (ANN) approach specifically back propagation network (BPN) and probabilistic neural network (PNN) for the identification of brain tumor class (grade) in MR Images of various brain tumor patients with Astrosytama type tumor. Gray level co-occurrence matrix (GLCM) is used for the feature extraction. The entire system functions in two phases as Training/ Learning phase and Testing/Recognition or classification phase.*

Index terms: *Image processing, feature extraction, Gray Level Co-occurrence Matrix (GLCM), Artificial Neural Network (ANN), Back Propagation Network (BPN), Probabilistic Neural Network (PNN).*

I. Introduction.

Automation in data processing has tremendously increased in recent past. Different fields of applications are implementing automation system for the easiness of usage and managing operations. Amongst various domains of usage medical image processing has attained an amazing interest in automation owing to its criticality in handling for real time functions. In medical image processing, medical images or video streams are processed in a progression to detect or guess critical medical concerns of the patient under observation. Amid different applications of medical diagnosis, tumor detection in brain MRI is a developing area. Of various investigation of medical scan information, MRI examination for brain tumor identification is noticed to be a forthcoming work. Automation of brain tumor identification for which now artificial neural networks are being incorporated helps in the preliminary diagnosis, and quicker decision making. An early detection of tumor saves the patient's life. The brain is an amazing organ of the human body that organizes all the activities of the body. It takes information from the external world and embodies the spirit of the brain and heart. Intelligence, creativity, movement, emotions and memory are some of the several things controlled by the brain. The brain has mainly two kinds of cells; Neurons and Glial cells. Glial cells are also called as glia or Neuroglia, which exist in many kinds and perform many important tasks along with structural support, metabolic support, insulation and development of guidance [1].

The Cells in the brain look differently and work differently. New cells in the brain are formed only when they are in need to substitute old cells or else damaged cells. Majority of the brain cells revamp themselves by dividing to produce new cells. Usually, this process happens in a controlled way. But due to any cause the progression gets out of control, the brain cells go on to divide themselves forming a lump, which is known as a tumor [2]. Brain tumor may be stated as "an uncharacteristic growth of brain cells in the brain or skull, which may be cancerous, or non-cancerous" brain tumor may expand at any age, however it is familiar among children aged among 3 and 12 years of age and in adults between the ages of 55-65 [2, 3]. Mainly there are two types of brain tumors, "primary brain tumors" and "metastatic brain tumors (secondary brain tumors)". Primary brain tumor starts and tends to reside in the brain. Metastatic brain tumor begins like a tumor somewhere else in the body and extends to the brain. There are two kinds of cells which constitutes the nervous organization:-

1) *Neurons: - These* transmit as well as receive nerve information.

2) *Neuroglia:* - These cells surround the neurons and are also called as glial cells. These cells support and protect the neurons. A brain tumor which occurs from glial cells is known as glioma. The most general kind of glioma is an astrocytoma [4].

Astrocytoma:- An astrocytoma occurs from star-shaped glial cells. These tumors may develop at any part in the brain; however the most usual place of this is in the frontal lobe. Astrocytomas are the most general primary central nerves system tumor.

Astrocytomas are commonly categorized as low or high grade. Low-grade astrocytomas grow very slowly, where as high-grade astrocytomas (grades three and four) spread very rapidly.

The World Health Organization (WHO) has classified astrocytomas into four grades (Classes) as [5],

1) Grade I tumor or Pilocytic Astrocytoma
2) Grade II tumor or Low-Grade Astrocytoma
3) Grade III tumor or Anaplastic Astrocytoma
4) Grade IV tumor or Glioblastoma Multiforme

The features of the astrocytoma depend on tumor grade and its locality. The objective of the presented paper is to suggest a diagnosis means for the detection of brain tumor. This paper proposes a brain tumor classification system, which classifies the grade (Class) of brain tumor from MR images using texture features on the basis of Gray Level Co-Occurrence Matrix (GLCM). To train the artificial neural network two modes of approach are described in two phases as Training/Learning phase and Testing/Recognition or Classification phase. Back propagation network (BPN) and Probabilistic neural network (PNN) are used to classify the brain tumor. The paper is further presented in six sections in addition to introduction. In section II image processing approach is presented. Section III outlines the feature extraction and Gray Level Co-occurence Matrix (GLCM). Section IV describes the classifier model with ANN. The experimental simulation results are presented in section V. Section VI concludes the suggested approach for the proposed system.

II. IMAGE PROCESSING APPROACH.

Image processing approaches are used to carry out image segmentation on input image. The image processing approach applied in the proposed system is illustrated in figure 1. The object of applying image processing is to separate the tumor region from the rest of the image. The first step to be used in the segmentation approach is histogram equalization. The histogram of an image denotes the relative repetitions of occurrence of different grey levels in the image. The main difficulty in the progression of detection of edge of the tumor is that, the tumor appears very dark on the image which is very puzzling. To overcome this issue, Histogram Equalization was performed. Histogram equalization employs a monotonic, non linear mapping which re-assign the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. Segmentation subdivides an image into its constituent parts or objects. The level to which this sub division is carried depends on the problem being solved. i.e. the segmentation should stop when the edge of the tumor is able to be detected. Thresholding has been used for segmentation as it is most suitable for the present system in order to attain a binarized image with gray level 1 representing the tumor and gray level 0 representing the background [2]. In an easy realization, the segmentation is decided by a single parameter known as the Intensity Threshold. For the binarization of equalized image a thresholding approach is used as shown below. Binarized Image bi, j = 255 if e (i, j) > T Else bi, j = 0 Where e (i, j) is the equalized MR image and T is threshold resultant for the equalized image. Threshold can be described by following equation.

$$T = \frac{\sum(e_s(i,j) X s(i,j))}{\sum s(i,j)} \quad \text{-----------------} \quad (1)$$

Where, $s(i,j) = \max(|g_1 ** e_s(i,j)|, |g_2 ** e_s(i,j)|)$

And, $g_1 = [-1\ 0\ 1], g_2 = [-1\ 0\ 1]^t$

Using Equation 1 threshold 'T' can then be calculated, and the test image ($\boldsymbol{e}$) is given by,

$$e(i,j) = \begin{cases} 255, if\ e_s(i,j) > T \\ 0, otherwise \\ 1 \end{cases} \quad \text{--------} \quad (2)$$

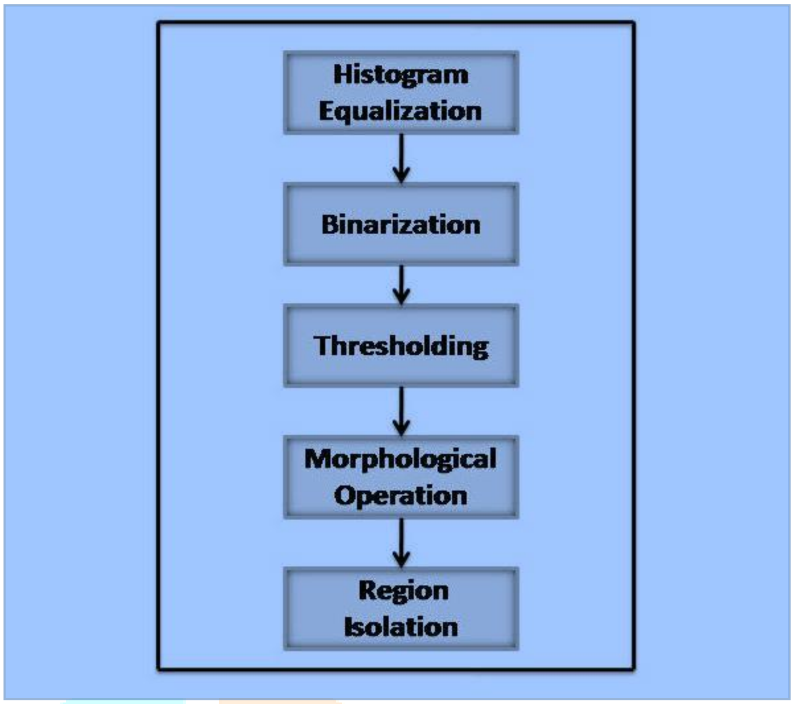

Figure1. Image processing approach.

The basic improvement required is to enlarge the contrast among the entire brain and the tumor. Contrast among the brain and the tumor region may be present but less than the threshold of human perception [2]. Morphological operation is used as an image processing tools for sharpening the regions and filling the gaps for binarized image [2]. The dilation operation is performed by “imdilate” command ANN Approach Based on Back Propagation Network and Probabilistic Neural Network to Classify Brain tumor in “MATLAB”. This is applied for filling the broken gaps at the edges and to have continuity at the boundaries. A structuring element of 3x3 square matrix is applied to complete dilation operation. After filling operation on an image; centroids are calculated to localize the regions. The final extracted region is then logically operated for extraction of massive region in the given MRI image.

III. FEATURE EXTRACTION.

On the extracted area of interest, a feature extraction is performed, where each of the extorted areas is processed for GLCM feature extraction for the selected spectral band. In the selection of feature, it is principally required that no extra coefficient should be added, which will lead to overhead, and the feature must be so chosen that no information value is eliminated. With this objective, in this work a spectral selective feature model is proposed. The spectrally chosen bands are processed for GLCM Harlick feature extraction which is then used for classification modeling [6, 7].

a) TEXTURE FEATURES.

Normally texture is a feature used in the examination and understanding of images. Texture is described by a group of local statistical characteristics of pixel intensities [3]. When the Grey Level Co-occurrence Matrix is generated, the textures feature can be calculated from the GLCM. The seven common textures features described here are angular second moment (ASM) or energy, contrast, inverse difference moment (IDM) or homogeneity, dissimilarity, entropy, maximum probability and inverse. Energy is as well identified as uniformity of ASM (angular second moment) which is the sum of squared elements from the GLCM [4]. Contrast is used to evaluate the local variations. Homogeneity is to assess the distribution of elements in the GLCM with respect to the diagonal. Entropy gauges the statistical randomness. The seven common textures features are describe in equation 3 to 11. All these features are extracted using GLCM method in four directions (i.e. 0º, 45º, 90º and 135º) for each feature and texture features are computed [10].

b) GRAY LEVEL CO-OCCURRENCE MATRIX (GLCM) FEATURES.

GLCM is a statistical method that can describe the second-order statistics of a texture image. Gray level co-occurrence matrix (GLCM) was first introduced by Haralick. A gray-level co-occurrence matrix (GLCM) is basically a two-dimensional histogram. The GLCM approach considers the spatial association among pixels of dissimilar gray levels [3]. The approach computes a GLCM by considering how frequently a pixel with a definite intensity i take place in relative with other pixel j at a definite distance d and orientation θ [3]. A co-occurrence matrix is specified by the relative frequencies P (i, j, d, θ). A co-occurrence matrix is hence a function of distance d, angle θ and grayscales i and j. In the proposed system MRI image can be decomposed into patterns with regular textures. So we should be competent to signify these regular texture regions by using co-occurrence matrices. To accomplish that, we make use of the co-occurrence matrices in angles of 0°, 45°, 90°, and 135° for extracting the significant feature for image detection. This extracted feature gives the nature of the text characteristic that may be used for training in the database. Then trained features are matched with the features obtained from the test sample and classified as one of the extracted characters. For classifying the normal and abnormal tumors, texture features or more specifically Gray Level Co-occurrence Matrix (GLCM) features are used [7]. Five co-occurrence matrices are formed in four spatial directions: horizontal, right diagonal, vertical and left diagonal (0^0, 45^0, 90^0, and 135^0). A fifth matrix which is the mean of the preceding four matrices is constructed. A set of five features are taken out from each co-occurrence matrix in different directions to train the neuro-model. Let P be the NxN co-occurrence matrix computed for every sub-image, then the features by Byer is given as,

1. Maximum Probability

$$f_1 = \max_{i,j} P(i, j) \quad \text{------------------------- (3)}$$

2. Contrast

$$f_2 = \sum_{j=0}^{N-1} P_{i,j}(i-j)2 \quad \text{----------------- (4)}$$

3. Inverse Difference Moment (Homogeneity)

$$f_3 = \sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2} \quad \text{--------------------- (5)}$$

4. Angular Second Moment (ASM) ---------------------------------(6)

$$f_4 = \sum_{i,j=0}^{N-1} P^2_{i,j}$$

5. Dissimilarity ----------------------------- (7)

$$f_5 = \sum_{i,j=0}^{N-1} P_{i,j} \left| i-j \right|$$

6. Gray Level Co-occurrence Mean (GLCM) ------------------------- (8)

$$f_6 = \mu i \sum_{i,j=0}^{N-1} i(P_{i,j})$$

7. Varience ------------------------ (9)

$$f_7 = \sigma i = \sum_{,j=0}^{N-1} P_{i,j}(i - \mu_i)^2$$

8. Correlation Coefficient ----------------- (10)

$$f_8 = \sum_{i,j=0}^{N-1} \left(\frac{P_{i,j}}{(i - \mu_i)(j - \mu_j)\sqrt{(\sigma^2_i)(\sigma^2_j)}} \right)$$

Where

$$\mu_j = \sum_{i,j=0}^{N-1} j\,(P_{i,j})$$

$$\sigma_j = \sum_{i,j=}^{N-1} (P_{i,j}(j - \mu_j)^2$$

9. Entropy

$$f_9 = \sum_{i,j=0}^{N-1} P_{i,j}(-\ln P_{i,j})$$ ----------------------- (11)

Feature selection requires the reduction of pattern space and recognition of features which contain maximum information that is useful for differentiating normal and abnormal cases. Classifier design can be simplified by selecting efficient features. Hence, features were selected on the basis of correlation coefficient among features. The correlation matrix was computed for a set of nine texture features for normal as well as abnormal regions.

IV. CLASSIFIER MODELING.

For the modeling of classifier unit, SVM based classifier unit with the fusion of a neural coding is presented. The classifier model uses the features extracted for training, where rather to a 1-to-1 class modeling, a multiclass learning model is suggested. This approach is used in training the SVM model with minimal class error. The multi class SVM is trained with the artificial neural network model, where multiple classes are trained with a feed forward neural network (FFNN) [8].

a) BACK PROPAGATION ARTIFICIAL NEURAL NETWORK

Back propagation is a supervised learning approach. In supervised learning, every input vector requires a corresponding target vector. Input vector and target vector are presented in training of the network. The output vector (i.e. actual output) which is result of the network is compared with the target output vector. Then an error signal is generated by the network. This error signal is used for adjustment of weights until the actual output matches the target output. Algorithm stages for BPN are initialization of weights, feed forward, back propagation of Error and updation of weights and biases [9, 10, and 11].

b) PROBABILISTIC NEURAL NETWORK

Probabilistic Neural Networks (PNN) is a type of radial basis network appropriate for classification purpose. A PNN is principally a classifier since it can map any input pattern to a number of classifications, that is Probabilistic neural networks can be used for classification issues. When an input is given, the first layer computes distances from the input vector to the training input vectors and produces a vector whose elements specify how close the input is to a training input. The second layer sums these contributions for every class of inputs to produce as its net output a vector of probabilities. Finally, a compete transfer function on the output of the second layer picks the maximum of these probabilities. PNN is a fast training process and an inherently parallel structure that assured to converge to a best possible classifier as the size of the representative training set increases and training samples can be added or removed without extensive retraining [10, 11]. The proposed system architecture for the detection and classification of brain tumor is shown in fig.2. This works in two phases, namely Training/Learning phase and Testing/Classifying or recognition phase [13].

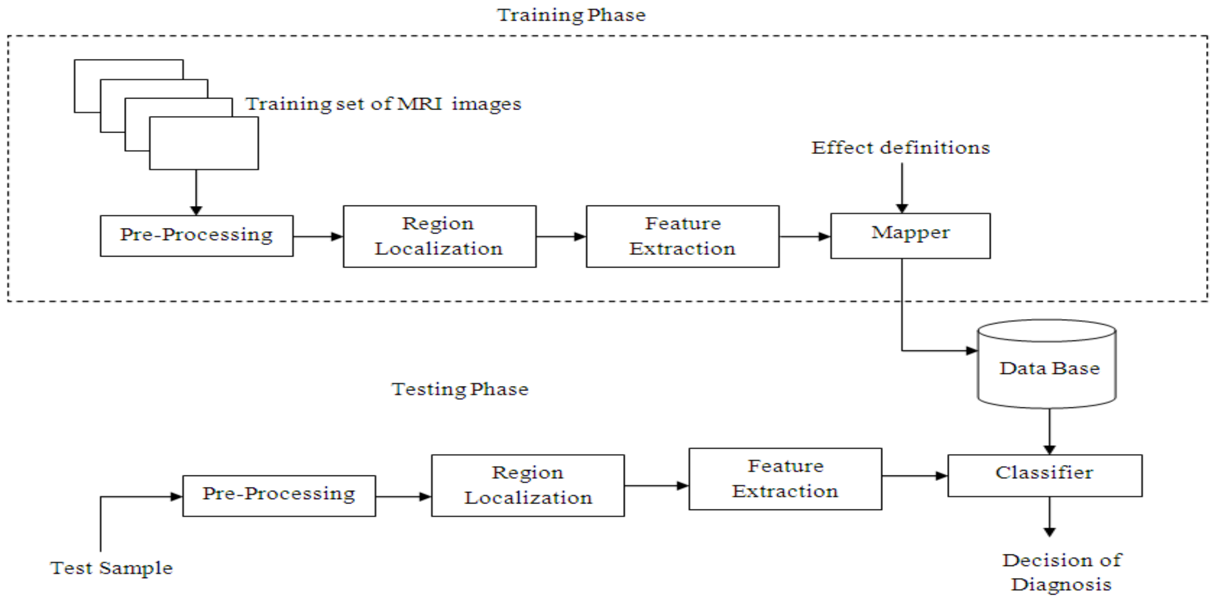

Figure 2: Proposed system architecture for the detection and classification of brain tumor.

(1) Training/Learning phase: - The first phase of working in the proposed system is Training /Learning phase. In this phase the ANN is trained for recognition of different kinds of Astrocytoma brain tumors. The known MRI images are first processed through different image processing steps such as Histogram Equalization, Thresholding, and morphological operation etc. and then textural features are extracted using Gray Level Cooccurrence Matrix. The features extracted are used in the training/learning phase. Knowledge base, which helps in successful classification of unknown Images. These features are normalized in the range -1 to 1 and given as an input to Back Propagation Neural Network (BPN) based Classifier. In case of Probabilistic Neural Network (PNN) these features are directly given as an input to PNN based classifier. The features such as angular second moment (ASM) or energy, contrast, inverse difference moment (IDM) or homogeneity, dissimilarity, entropy, maximum probability and inverse for each type of MRI image was trained for the neural network.

(2) Testing/Classification phase: - The second phase of working of the proposed system is testing/ Classification or Recognition phase. To test the unknown MRI image sample and classify, two steps are performed, the first one is segmentation of the test image and computation of the GLCM for each input MRI image. The obtained GLCM is used to extract features. The second step in this phase is train the above features with the desired values of neural networks to determine the MRI image belonging to which grade (class) of astrocytoma brain tumor. The decision taken to classify the grade of the brain tumor is completed by back propagation neural network (BPN) based and probabilistic neural network (PNN) based classifier.

V. EXPERIMENTAL RESULTS.

The assessment of the proposed method is presented by testing different test samples for segmentation, feature-extraction and categorization. The classifier result in the type of tumor effect is detected. The classifier model is evaluated for the class (grade) result diagnosis. The obtained result shows an improvement in accuracy, sensitivity, recall rate and computational time when compared with other existing approaches. The simulation results of the present research are shown in from figure1to figure 4 for different classes (grade) of tumors. The accuracy, Sensitivity, Recall rate Computational time of the proposed system has been considerably improved compared with the similar existing systems.

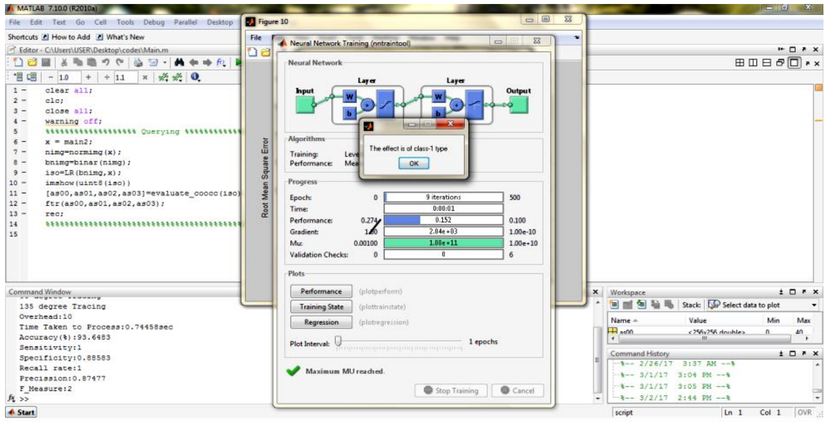

Figure 1: Simulation results of class-I type tumor

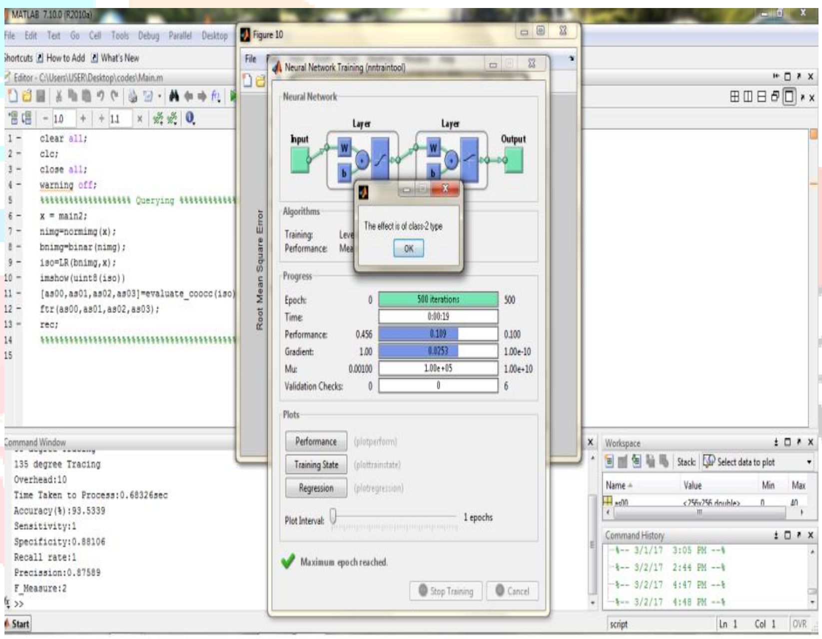

Figure 2: Simulation results of class-II type tumor

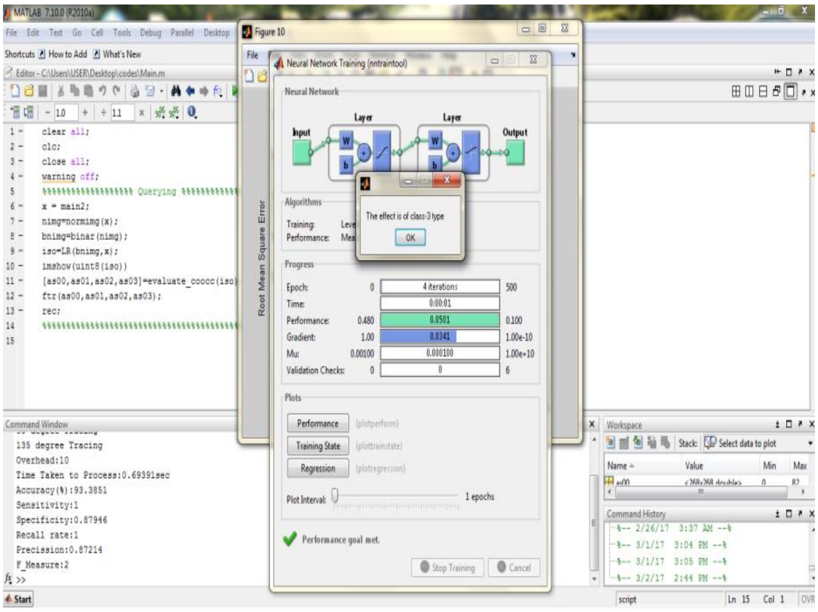

Figure 3: Simulation results of class-III type tumor

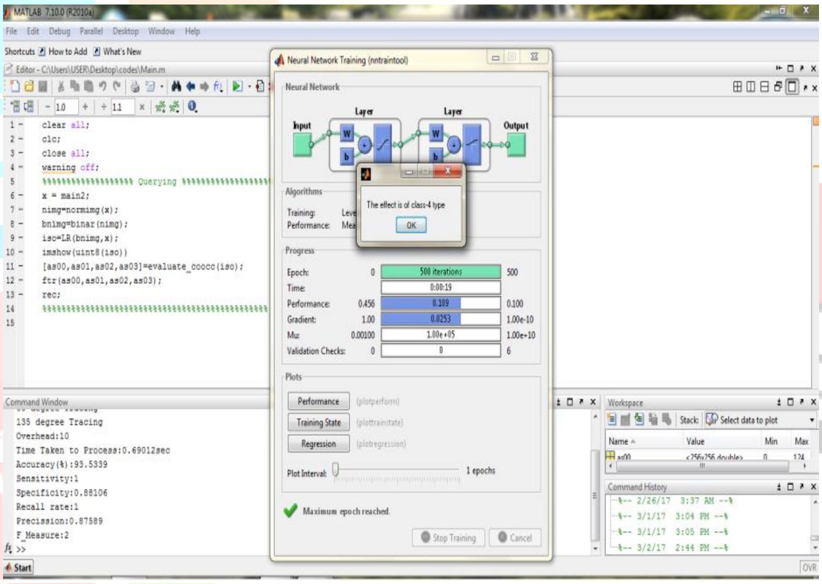

Figure 4: Simulation results of class-IV type tumor

IV.Conclusion

The presented paper describes the detection and Classification (grade) of Brain tumor using Artificial Neural Network approach specifically, Back propagation network (BPNs) and Probabilistic Neural Network (PNN). The Complete system functions in two phases as Training/Learning phase and Testing/Recognition phase. The image processing means such as histogram equalization, binarization, thresholding, morphological operation and region isolation are performed on Training/Learning and testing/Classification or Recognition MR Image samples. Texture features are used in the Training/Learning of the Artificial Neural Network. Co-occurrence matrices at 0º, 45º, 90º and 135º are calculated and Gray Level Co-occurrence Matrix (GLCM) features are extracted from the matrices. The suggestive approach classifies the tumor class (grades) in brain MRI images more efficiently. The accuracy, Sensitivity, Recall rate and Computational time of the proposed system has been improved considerably compared with similar existing systems.

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